

Claims

1. A control system for a rotorcraft comprising:
  - a cyclic for receiving pilot input commands;
  - a torque tube pivotally coupled to the cyclic;
  - a forward-aft output link pivotally coupled to the torque tube for transmitting forward-aft pilot input commands to a main rotor;
  - a stepped mixing linkage pivotally coupled to the torque tube;
  - a ground link pivotally coupled between the stepped mixing linkage and a grounded structure;
  - a lateral output link pivotally coupled to the stepped mixing linkage; and
  - a left-right output link pivotally coupled to the lateral output link for transmitting left-right pilot input commands to the main rotor;wherein the stepped mixing linkage, the ground link, and the lateral output link are configured to generate a selected lateral sinusoidal output, a selected rotation of the sinusoidal output, and a selected ramped output in response to each forward-aft cyclic input command.
2. The control system according to claim 1, wherein the stepped mixing linkage generates a selected left lateral cyclic output in response to a selected forward cyclic input, and the stepped mixing linkage generates a selected right lateral cyclic output in response to a selected aft cyclic input.
3. The control system according to claim 1, wherein the stepped mixing linkage comprises:
  - two supporting links pivotally coupled to the torque tube; and
  - a floating link pivotally coupled between the two supporting links, the floating link having a central reference point;wherein the ratio of the lengths of the two supporting links to the length of the floating link is small, thereby generating the selected lateral sinusoidal output.

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4. The control system according to claim 3, wherein the two supporting links are pivotally coupled to the torque tube at a selected angle to the lateral output link, thereby generating the selected rotation of the sinusoidal output.
5. The control system according to claim 3, wherein the lateral output link is angled relative to the torque tube, thereby generating the ramped output.
6. The control system according to claim 3, wherein the support links are pivotally coupled to the torque tube, such that their pivot points form a parallelogram;  
wherein one of the support links is pivotally coupled to the ground link; and  
wherein the lateral output link is pivotally coupled to the stepped mixing at the reference point and disposed at an angle to the support links;  
thereby generating the selected rotation of the sinusoidal output and the selected ramped output.
7. The control system according to claim 1, wherein the stepped mixing linkage comprises:  
a Watts linkage having two supporting links and one floating link, wherein the ratio of the lengths of the two supporting links to the length of the floating link is small, thereby generating the selected lateral sinusoidal output.
8. The control system according to claim 1, wherein the stepped mixing linkage comprises:  
two supporting links pivotally coupled to the torque tube; and  
a floating link pivotally coupled between the two supporting links, the floating link having a central reference point;  
wherein the lengths of the two supporting links are about the same as the length of the floating link, thereby generating the selected lateral sinusoidal output.
9. A rotorcraft comprising:  
a fuselage;  
a drive means carried by the fuselage;

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a main rotor coupled to the drive means; and

a control system comprising:

a cyclic for receiving pilot input commands;

a torque tube pivotally coupled to the cyclic;

a forward-aft output link pivotally coupled to the torque tube for transmitting forward-aft pilot input commands to a main rotor;

a stepped mixing linkage pivotally coupled to the torque tube;

a ground link pivotally coupled between the stepped mixing linkage and a grounded structure;

a lateral output link pivotally coupled to the stepped mixing linkage; and

a left-right output link pivotally coupled to the lateral output link for transmitting left-right pilot input commands to the main rotor;

wherein the stepped mixing linkage, the ground link, and the lateral output link are configured to generate a selected lateral sinusoidal output, a selected rotation of the sinusoidal output, and a selected ramped output in response to each forward-aft pilot input command.

10. The rotorcraft according to claim 9, wherein the control system generates a selected left lateral cyclic output in response to a selected forward cyclic input and, a selected right lateral cyclic output in response to a selected aft cyclic input.

11. The control system according to claim 9, wherein the stepped mixing linkage comprises:

two supporting links pivotally coupled to the torque tube; and

a floating link pivotally coupled between the two supporting links, the floating link having a central reference point;

wherein the ratio of the lengths of the two supporting links to the length of the floating link is small, thereby generating the selected lateral sinusoidal output.

12. The control system according to claim 11, wherein the two supporting links are pivotally coupled to the torque tube at a selected angle to the lateral output link, thereby generating the selected rotation of the sinusoidal output.

13. The control system according to claim 11, wherein the lateral output link is angled relative to the torque tube, thereby generating the ramped output.

14. The control system according to claim 11, wherein the support links are pivotally coupled to the torque tube, such that their pivot points form a parallelogram;  
wherein one of the support links is pivotally coupled to the ground link; and  
wherein the lateral output link is pivotally coupled to the stepped mixing at the reference point and disposed at an angle to the support links;  
thereby generating the selected rotation of the sinusoidal output and the selected ramped output.

15. A stepped mixing linkage for use on an existing rotorcraft having a control system including a cyclic for receiving pilot input commands, a torque tube pivotally coupled to the cyclic, a forward-aft output link pivotally coupled to the torque tube for transmitting forward-aft pilot input commands to a main rotor, and a lateral output link pivotally coupled to the torque tube for transmitting left-right pilot input commands through a left-right output link to the main rotor, the stepped mixing linkage comprising:

two supporting links adapted for pivotal coupling to the torque tube;  
a floating link pivotally coupled between the two supporting links, the floating link having a central reference point; and

a ground link pivotally coupled between one of the supporting links, the ground link being adapted for pivotal coupling to a grounded structure on the existing rotorcraft;

wherein the ratio of the lengths of the two supporting links to the length of the floating link is small, thereby generating a selected lateral sinusoidal output, a selected rotation of the sinusoidal output, and a selected ramped output in response to each forward-aft pilot input command.

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16. A method of eliminating the cross-coupling effect in a rotorcraft comprising the steps of:

- providing a cyclic for receiving pilot input commands and transmitting the pilot input commands to a main rotor;

- pivotaly coupling a torque tube to the cyclic;

- pivotaly coupling a forward-aft output link to the torque tube;

- pivotaly coupling a stepped mixing linkage to the torque tube;

- providing a stepped mixing linkage having two supporting links, a floating link pivotaly coupled between the two supporting links, and a central reference point on the floating link;

- pivotaly coupling the stepped mixing linkage to the torque tube;

- pivotaly coupling a ground link between one of the supporting links and a grounded structure;

- pivotaly coupling a lateral output link to the floating link at the reference point;
- and

- pivotaly coupling a left-right output link pivotaly the lateral output link through a bellcrank; and

- generating a selected lateral sinusoidal output, a selected rotation of the sinusoidal output, and a selected ramped output with the stepped mixing linkage, the ground link, and the lateral output link in response to each forward-aft pilot input command.